CONFERENCE ON SCIENCE AT THE SANFORD UNDERGROUND RESEARCH FACILITY

Book of Abstracts

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

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Materials Science / 30

Purification of Ge ingots for growing crystals in developing dark matter detectors

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High-purity germanium (HPGe) single crystal having the net impurity level of ~10^9 to 10^10 cm^-3 can be used for the fabrication of high-resolution Dark matter detectors. We implement Zone refining technique as a primary purification procedure for growing crystals. The raw germanium ingots in our laboratory have four main impurities, such as Aluminum (Al), Boron (B), Phosphorous (P) and Gallium (Ga), isolated to different parts of the ingot, which have been identified through photothermal ionization spectroscopy (PTIS), with net impurity level of (10^13-10^14) cm^-3. In order to setup zone refine germanium crystals, it is very important to take care of cleaning and etching procedure, additionally vacuum levels and the correct combination of ambient gases. The process of zone-refining included two-step strategy, which included initial purification of the raw germanium ingots in graphite boat, and then further purification of the zone-refined ingots from the first step in the carbon-coated quartz boat. We have optimized the parameter, zone length, zone travel speed and the number of passes for impurities ingots having distinguished segregation coefficient. Using the Van der Pauw Hall method, we were able to measure the electrical properties of zone refined ingots and analyze the distribution of impurities. Results obtained from Graphite boat Ingots have the impurity level of (10^11-10^12) cm^-3 and from Quartz boat Ingots (10^10-10^11) cm^-3. This work is supported by NSF OISE-1743790 and NSF PHY-1902577.

Low Background Workshop / 63

DarkSide 20k Materials Assay

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A brief description of the DarkSide 20k materials screening and radioactive budget will be described.

Parallel - Dark Matter II / 53

Results and Plans of DarkSide

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DarkSide is a program that searches for Dark Matter using low radioactivity argon in a two phase Time Projection chamber. DarkSide-50 is the first physics grade detector with approximately 50 kg of fiducial argon. After a few years of detector operation, we present results of our blind analysis of a (16,660+-270) kg d exposure. We find no events in the dark matter selection box and set a 90% C.L. upper limit on the dark matter-nucleon spin-independent cross section of 1.14 10-44 cm2 for a WIMP mass of 100 GeV/c2. In addition, we will briefly describe the plans for the larger detector, DarkSide-20k, which is in design and will have approximately 800 times the fiducial volume.

Low Background Workshop / 67

Ultra Low Background Front End Electronics for the Majorana Demonstrator

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Shielding requirements for low background HPGe detection systems require non-radiopure readout electronics to be placed some distance away from the detector. This distance adds additional capacitance and sensitivity to microphonic noise, both of which can affect the energy resolution and ultimately the region of interest for experiments in neutrinoless double beta decay. For this reason, many detection systems place the first transistor of the preamplifier in physical proximity to the detector, constituting the "front end" or "very front end" portion of the preamplification electronics. This physical proximity then places stringent demands on the radiopurity of the front end and its materials. This talk will describe the methods used to design, fabricate and test the low mass front end (LMFE) developed and deployed for the Majorana Demonstrator.

Materials Science / 28

Deep level impurity characterization in developing Germanium detectors for detecting rare event physics

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Deep-level impurity impacts germanium detector performance in terms of charge trapping and charge carrier recombination that will eventually broaden energy resolution of germanium detectors. Deep-level impurity characterization in semiconductors is performed widely nowadays using Deep level transient spectroscopy (DLTS) technique. In this technique, the junction is reversed bias and pulse voltage is provided so that the majority charge carrier is in the depletion region. The thermal emission of holes from the deep level in the forbidden gap gives capacitance transient which is measured by the boxcar method. I will talk about the basic DLTS theory, experimental components and different peaks due to the deep level we found in high purity Germanium samples. Using this technique, the deep level traps due to doubly ionized copper and

copper-Hydrogen complexes were positively identified. Several unknown traps were also observed.

This work is done under the collaboration PIRE-GEMADARC. It was sponsored by NSF OISE-1743790 and NSF OIA-1738632. I would also like to thank Dr.Eric Lukosi and Joint institute of advanced materials(JIAM),Knoxville Tennessee for providing the facility to conduct our research

Parallel - Dark Matter III / 12

HeRALD: Probing Sub-GeV Dark Matter with Superfluid Helium-4

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We present the Helium Roton Apparatus for Light Dark Matter (HeRALD), which will use superfluid helium-4 to probe the sub-GeV weakly interacting dark matter parameter space. In addition to detecting singlet and triplet excimers formed by particle recoils in the helium target, our proposed design is sensitive to roton and phonon excitations by detecting the helium atoms they eject from a superfluid-vacuum interface. These helium atoms are detected by surface binding to bolometry suspended in the vacuum above the detector mass. I will present sensitivity projections for this detector concept to new areas of low-mass parameter space, including its reach with existing technology and prospects for the future. I will also discuss current R surrounding the HeRALD project and our progress towards realizing a prototype detector.

Parallel - Dark Matter III / 9

The SABRE Dark Matter Experiment

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The interaction rate of dark matter particles in a terrestrial detector is expected to undergo an annual modulation due to the Earth's orbital motion. The DAMA experiment has observed such a modulation with high significance in an array of scintillating NaI(Tl) crystals. However, no other experiment has verified the DAMA signal in a model independent fashion. SABRE aims to perform a definitive model-independent test of the DAMA claim. SABRE will have a lower background in the signal region and a lower energy threshold thanks to high purity crystals and a 4π liquid scintillator veto. SABRE is also a two-site experiment, with a detector in Italy (Gran Sasso National Laboratory) and another detector in a new underground laboratory in Australia (Stawell Underground Physics Laboratory). This twin detector design both controls for seasonal systematics and offers a confirmation of the global nature of a modulation signal, if found. This talk will give an overview of the SABRE design and sensitivity, and provide an update on the current activities including the Proof-of-Principle detector at LNGS and characterisation measurements.

Low Background Workshop / 21

Evaluation of Radon Emanation and Diffusion for SuperCDMS SNOLAB

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The SuperCDMS SNOLAB dark-matter experiment, now under construction, will use Si/Ge detectors as targets in an effort to detect dark matter particles. A purged radon barrier, used to reduce the background from gamma rays emitted by radon daughters within the experiment's lead shield, must be constructed with gaskets having low radon emanation and diffusion. I will describe the radon emanation system at SDSM as well as a low-cost set-up to measure radon diffusion and permeability. I will present measurements of radon emanation, diffusion, and solubility of gasket materials and describe improvements for radon emanation measurements under development.

Parallel - Dark Matter II / 49

Status of the LZ Experiment

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LUX--ZEPLIN (LZ) is a dark matter experiment under construction at the 4850' level of the Sanford Underground Research Facility in Lead, South Dakota. The experiment utilizes a two-phase time projection chamber (TPC), containing seven active tonnes of liquefied xenon, to search for weakly interacting massive particles (WIMPs). Auxiliary veto detectors, including a liquid scintillator outer detector, improve rejection of unwanted background events in the central region of the detector. LZ has been designed to explore much of the parameter space available for WIMP models, with excellent sensitivity for WIMP masses between a few GeV and a few TeV. With data taking expected to begin in 2020, this talk will report the current status of the LZ experiment.

*This work was supported in part by the Department of Energy (Grants No. DE-SC0014223 and DE-AC02-05CH11231).

Low Background Workshop / 54

Radon Emanation Assay Results for the LZ Experiment

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LUX-ZEPLIN (LZ) is a dark matter experiment under construction at the 4850' level of the Sanford Underground Research Facility (SURF) in Lead, South Dakota. The experiment utilizes a two-phase time projection chamber (TPC), containing seven active tonnes of liquefied xenon, to search for weakly interacting massive particles (WIMPs). LZ is designed to explore much of the parameter space available for WIMP models, with excellent sensitivity for WIMP masses between a few GeV and a few TeV. In order to achieve this goal, LZ has implemented a strict background control strategy with all materials undergoing a comprehensive screening campaign. In the WIMP region of interest, the dominant background is due to radon emanating from components in direct contact with the LXe. Four radon-emanation screening facilities, as well as two portable emanation systems, assay sensitive detector components prior to the actual assembly to ensure the strict radio purity requirements of LZ are met. This talk will give an overview of the radon emanation systems and summarize the results of the LZ radon assays.

Plenary - Underground Physics & Materials Science / 46

Radiopure Material Development for Next Generation 0vBB Experiments

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High purity underground electroformed copper continues to play an important role for certain ultra-low-background detector experiments. Measurements of rare nuclear decays, e.g. neutrinoless double-beta decay, require construction materials that have high thermal and electrical conductivity with bulk radiopurity less than one micro-Becquerel per kilogram. However, experiments currently using components constructed of radiopure electroformed copper struggle with design of structural and mechanical parts due to the physical properties of pure copper. A higher strength material which possesses many of the favorable attributes of copper yet remains radiopure is desired. Exploration of chromium copper alloying techniques may provide improved mechanical performance and adequate radiopurity. Development of an electrodeposited copper-chrome alloy from additive-free electrolyte systems is discussed. The resulting material is shown to possess high strength and meets the radiopurity goals while solving several potential problems as experiments scale to a ton capacity with larger volume systems.

Parallel - Dark Matter II / 44

Results from XENON1T and status of the XENONnT upgrade

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The XENON1T experiment utilizes a liquid xenon time-projection chamber with a 1.3 tonne fiducial volume to search for direct collisions of Weakly Interacting Massive Particles (WIMPs) with xenon nuclei. XENON1T has produced the most stringent limits on the spin-independent WIMP-nucleon scattering cross-section and the spin-dependent WIMP-neutron cross-section to date for masses above 6 GeV using a 1 tonne yr exposure. The experiment has also produced other physics measurements, such as the double electron capture decay of xenon-124. The detector is currently being upgraded to the next phase of the experiment, known as XENONnT, increasing the target mass by a factor of three and reducing backgrounds while reusing the established infrastructure of XENON1T. XENONnT is planned to be operational by the end of 2019.

Plenary - Dark Matter / 73

Dark Matter Searches with Solid-State Detectors

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Solid-state detectors have made remarkable progress in the past few years, probing new parameter space in the search for the constituents of dark matter. In this talk, I will review some of the techniques and technologies used by the collaborations who employ these detectors and highlight recent results from leading experiments.

Parallel - Dark Matter III / 6

SubGeV Dark Matter searches with EDELWEISS

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The EDELWEISS collaboration is performing direct searches for light Dark Matter particles using cryogenic germanium detectors equipped with a charge and thermal signal readout. This versatile and highly performing technology opens new possibilities for searches for signals in the subGeV region, involving either electrons or nuclear recoils. This is attested to by results on Axion-Like Particles in the keV range, and by the attainment of the first sub-GeV spin-independent dark matter limit based on a germanium target. The search has been extended to Strongly Interacting Particles (SIMP) down to 45 MeV by exploiting the Migdal effect. New results on SIMPs with spin-dependent interactions will also be presented. Future developments will be discussed.

Poster Session / 48

Emanation and Diffusion of Radon Through Gasket Materials for SuperCDMS SNOLAB

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The SuperCDMS SNOLAB experiment, currently under construction, will attempt to directly detect dark matter particles. Shielding surrounding the experiment's detectors will reduce interactions of particles from radioactivity and cosmic rays. A gas purge will remove radon from gaps in the shielding to reduce backgrounds further. Gaskets used to seal this purge volume must allow sufficiently low radon diffusion through them while emanating little radon into the purge

volume. I will describe measurements of radon diffusion through gaskets made of EPDM, Zip-A-Way, and Silicone, inferred from the time dependence of radon concentration in a volume

separated from a high-radon volume by the gasket in question. Results of these diffusion measurements and of the radon emanation measurements will be given in the presentation.
*This work was supported in part by the National Science Foundation (Grant No. PHY-1506033)

Plenary - Neutrinoless Double Beta Decay / 75

Future experiments for double beta decay

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The status and potential of future and next generation neutrinoless double beta decay experiments will be discussed.

Plenary - Neutrinoless Double Beta Decay / 76

Developments in the Theory of Double-Beta Decay

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The theoretical background of the neutrinoless double beta decay will be presented and its consequences for the standard model of nuclear and particle physics.

Poster Session / 20

Design and Simulation of a 9 MeV Gamma-Ray Calibration Source for Deployment in the Deep Underground Neutrino Experiment (DUNE) at Sanford Lab

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The Deep Underground Neutrino Experiment (DUNE) is scheduled to have its first 10 kton liquid argon detector module at Sanford Underground Research Facility (SURF) operational in 2024. SURF is located in the former Homestake Mine in Lead, SD. The final DUNE far detector will be comprised of four individual 10 kton liquid argon modules.
Knowing the detector response to low-energy signals from supernova and solar neutrinos is key for being able to record such data in the first place and for the interpretation of the weak electronic signals from these astrophysical sources.
Requirements for a deployable calibration source are that it be survivable at cryogenic liquid argon temperatures (87 K), that the entire source body does not float, that it can be deployed and retrieved through sealable flanges with 20 cm diameter at the top of the detector cryostat, and that it still has enough neutron moderator material to initiate (n, gamma) nuclear reactions on an encapsulated target. Such produced gamma-ray energies can be high enough to achieve sufficient penetration probabilities into the inner active region of the detector. The baseline design is a 9 MeV gamma-ray calibration source that employs encapsulated Cf-252 providing spontaneous fission neutrons to initiate 58Ni(n, gamma) reactions on a natural nickel target inside a cylindrical Delrin moderator body that fits through the cryostat penetrations.
Results from computer simulations are presented that aim at validating the calibration source concept and the deployment scheme before actual construction of the source is initiated.

Low Background Workshop / 38

Mobile-Panel Measurements of Radon Emanation for the LZ Dark Matter Experiment

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LUX-ZEPLIN (LZ) is a liquid xenon dark matter experiment being built to search for Weakly Interacting Massive Particles (WIMPs). The expected dominant background of LZ is from daughters of radon that emanate from materials touching the liquid xenon. To measure and help minimize this background, materials are left to emanate in chambers and the radon is then collected and assayed. Gas panels are used to flow the radon sample from the emanation chambers to the alpha detector. A new mobile gas panel was built in order to harvest radon from detector components being assembled and tested at the Sanford Underground Research Facility (SURF) in Lead, SD. The new panel has an increased flow capacity to be used for larger items such as the LZ Inner Cryostat Vessel (ICV) and uses a portable trap so that radon collected can be moved with ease between the SURF and the radon counter housed at South Dakota School of Mines and Technology. Results from radon emanation measurements with the mobile gas panel will be presented.

Parallel - Neutrinoless Double-Beta Decay I / 58

Current Status and Future Prospects for KamLAND-Zen 800

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After looking for neutrinoless double beta decay from 2011 to 2015, KamLAND-Zen was able to set a 90% C.L. lower limit on the 0nbb halflife of 136Xe at 1.07e26 yrs, a world leading limit. The experiment recently completed an upgrade to double the amount of Xenon. Data taking on this much larger mass has begun, and is expected to continue for 5 years. The status of this upgrade and future prospects for the experiment and analysis will be presented.

Plenary - Underground Physics & Materials Science / 59

The Sanford Underground Research Facility

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Building on rich legacies in both mining and transformational science, the Sanford Underground Research Facility (SURF) has been operating for over 10 years as the nation's underground laboratory to advance compelling and transformational multidisciplinary research. An overview of the facility and the science program will be presented. SURF's unique characteristics present a number of scientific opportunities, and applications from new experiments and groups are welcome.

Plenary - Neutrino Oscillations / 26

Long-Baseline Neutrino Experiment NOvA and Comparison to T2K

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Parallel - Nucleon Decay & Astrophysics / 13

Search for baryon number violating processes at DUNE

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The Deep Underground Neutrino Experiment (DUNE) located at the Sanford Underground Research Facility, will offer unique capabilities to search for baryon number violating processes such as nucleon decay and neutron-antineutron oscillation. Detecting a baryon number violating process would be a breakthrough for beyond Standard Model physics. In this talk we will describe the techniques developed at DUNE to search for these events.

Parallel - Neutrinoless Double-Beta Decay II / 4

Status of NEXT

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The NEXT collaboration is pursuing a phased program to demonstrate high pressure xenon gas technology and depoy a ton-scale neutrinoless double beta decay experiment. In this talk I will present recent results from the NEXT-NEW demonstrator, give the status of the presently in-construction NEXT-100, and discuss the planned NEXT-Ton program. The talk will review both recent developments in electroluminescent gas TPC technology, and R toward barium ion tagging in high pressure xenon.

Parallel - Nucleon Decay & Astrophysics / 61

Underground Measurement of the 22Ne(α,n)25Mg and 22Ne(α,γ)26Mg Cross Sections at Low Energies

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The formation of the heavy elements is a mystery still in the process of being unraveled. Current theories propose nuclear reactions occurring within the stars throughout the universe. For one process, the s-process, a constant supply of neutrons is necessary, such as those released by the reaction 22Ne(α,n)25Mg. Experiments have explored higher energies, but current data for reaction at solar energies only reveal upper limits. Through utilization of CASPAR at SURF the goal of this research is to examine 22Ne(α,n)25Mg and its counterpart 22Ne(α,γ)26Mg at low energies.

Parallel - Dark Matter II / 14

A Next-Generation Liquid Xenon Observatory for Dark Matter and Neutrino Physics

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Dark Matter and Neutrino physics are at the forefront of particle physics research nowadays. Dual phase noble liquid xenon time projection chambers (TPC) have emerged as the leading detector technology in these two research areas by reaching unprecedented sensitivity. However, to this day, both Dark Matter and other Neutrino physics processes, like neutrinoless double- β decay, still elude detection. Consequently, now is the time to design the ultimate third-generation (G3) Dark Matter experiment in order to probe not only the largest possible range of Dark Matter candidates, but as many Neutrino processes from multiple important sources such as our Sun, the atmosphere, and Galactic supernovae. Such an experiment will therefore serve as a versatile astroparticle physics observatory, with a particularly broad science reach.

In this talk I will first review the operating principle of the liquid xenon TPC technology. Then, I will present the status of the current experiments, and the science reach of a G3 multipurpose xenon experiment.

Parallel - Neutrinoless Double-Beta Decay I / 10

Neutrinoless double beta decay with SNO+

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SNO+ is a multipurpose detector with the primary goal of measuring neutrinoless double beta decay, but with the opportunity to explore a broad range of physics. SNO+ is currently filled with ultra-pure water primarily for commissioning and calibration purposes. Over the next several months the detector will be filled with liquid scintillator and then subsequently loaded with 0.5% natural tellurium. I will discuss the current plans and expected sensitivity, as well as future prospects, for the neutrinoless double beta decay measurement with SNO+.

Plenary - Underground Physics & Materials Science / 60

Welcome

Dr. KOURIS, Demitris [1]

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Welcome Address by the Provost and Vice President of Academic Affairs of the South Dakota School of Mines & Technology.

Low Background Workshop / 33

A Toolbox for High Purity Germanium Detector Geometry Design

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High Purity Germanium Detectors typically have coaxial geometry and radial symmetry in cylindrical coordinates. The shape of the detector, the locations of features, and the dopant impurity concentration all play important roles in the electrical fields and depletion behavior of the detector. The electric potential in the Ge detector can be determined by solving Poisson's Equation with the appropriate boundary conditions. For the case of true coaxial geometry, it is possible to determine an analytical solution for the electric potential and field in the detector. For realistic geometries, the solution requires a numerical approximation.
A numerical approximation to solve Poisson's Equation was implemented using MATLAB™. The method of successive relaxation was used to converge to a solution. The speed of the convergence is enhanced by successive over-relaxation. Several schemes were implemented for determining the shape of the undepleted region (if any) in the Ge crystal for a given reverse bias of the diode. The model includes the capability to adjust the shape of any coaxial holes and heavily doped contacts as well as the effects of the impurity profile in the detector. This is of particular interest to the detector manufacturer, since the geometry of the detector can be adjusted specifically for the crystal ingot from which it will be fabricated. This toolbox leads to the capability to optimize the electric fields in the detector for maximizing detector efficiency and minimizing the rise time in charge collection while minimizing the operating voltage in the detector. Figure 1 plots a representative example of the electric potential in a p-type detector.

This presentation will cover the development of the detector fields toolbox, applications in low background detector fabrication, and future developments.

Parallel - Neutrinoless Double-Beta Decay II / 7

AMoRE: A neutrinoless double beta decay experiment

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The AMoRE (Advanced Molybdenum based Rare process Experiment) is looking for neutrinoless double beta decay of Mo-100 in molybdate based crystal scintillators by using a cryogenic technique. The crystals are equipped with metallic magnetic calorimeter (MMC) sensors for detection of both phonon and photon signals at a temperature range down to 10~20 mK. Simultaneous measurements of both thermal and scintillation signals produced by a particle interaction in the crystal by the MMC sensors will provide high energy resolution and efficient particle discrimination. The AMoRE-pilot, an R phase, had six 48deplCa100MoO4 crystals with a total mass of ~1.9 kg in the final configuration and was running at the 700-m-deep Yangyang underground laboratory (Y2L). After the completion of the AMoRE-pilot run in the end of 2018, the AMoRE-I is being prepared with ~6 kg of crystals, mostly 48deplCa100MoO4 and several R crystals such as Li2100MoO4 and Na2100MoO7, to be installed at the Y2L in this summer. The AMoRE-II with ~200 kg of molybdate crystals at the ~1,100 m deep underground laboratory (Yemilab) at Handeok iron mine, being excavated from March 2019 for a completion by the end of 2020, can improve effective Majorana neutrino mass sensitivity down to the level of inverted hierarchy of neutrino mass, 20-50 meV. We have already secured 80 kg of Mo-100 isotopes for the AMoRE-II. Results of the AMoRE-pilot and status of the AMoRE-I and AMoRE-II preparation will be presented.

Parallel - Dark Matter I / 8

COSINE-100: A WIMP dark matter experiment

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The COSINE experiment searches for interactions of Weakly Interacting Massive Particles (WIMPs) using an array of NaI(Tl) crystal detectors in the 700-m-deep Yangyang underground laboratory, Korea. The main goal is to check the annual modulation signal observed by DAMA/LIBRA with the same target material. The first phase of the experiment, COSINE-100 with ~106 kg of NaI(Tl) crystals, has been running stably for more than 2 years. Several analyses in addition to the annual modulation have been actively ongoing, based on the 2 keV energy threshold and about 3 counts/day/kg/keV background rate in an energy region between 2 and 6 keV. In this talk, the detector performance, recent analysis results, and future prospects of the COSINE experiment will be presented.

Plenary - Neutrino Oscillations / 25

Theory Overview on Neutrino Oscillations

LI, Shirley [1]

[1] Stanford Linear Accelerator Center

The discovery of neutrino oscillation confirmed that neutrinos have mass. Since then, we have established a three-flavor neutrino oscillation paradigm. The next generation of oscillation experiments aims to measure the last unknown mixing parameters: the CP violation phase and the mass hierarchy. However, these are not the only interesting measurements that these experiments can make. The ultimate goal of the oscillation program is to over-constrain the PMNS matrix, exploiting the physics potential of every oscillation channel. I will discuss the exciting possibility of measuring solar neutrinos in the Deep Underground Neutrino Experiment (DUNE) and the unique physics opportunities that it can bring.

Plenary - Dark Matter / 74

Dark Matter Searches with Liquid Nobles

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Liquid noble gases have proven to be one of the best targets in direct dark matter searches. In this talk, I will give a summary of why liquid noble gases make good dark matter detection media, provide a snapshot of recent results, and talk about some new techniques that have been proposed to deploy liquid noble gases to search for light dark matter.

Low Background Workshop / 45

The nEXO background control program

Prof. MACLELLAN, Ryan [1]

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nEXO is a next generation, tonne scale, neutrinoless double-beta decay experiment aiming for a sensitivity on the decay of about 10^-28\,y. To achieve the maximum sensitivity from the experiment, nEXO has implemented a rigorous background control program utilizing an extensive array of materials analysis techniques. I will detail the nEXO background control program and its capabilities with a focus on our germanium detectors.

Parallel - Neutrino Oscillations II / 71

The Daya Bay Reactor Neutrino Experiment

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The Daya Bay Reactor Neutrino Experiment consists of eight functionally identical detectors placed underground at different baselines from six 2.9 GWth nuclear reactors. With a growing dataset that constitutes the largest sample of reactor antineutrino interactions ever collected to date, Daya Bay is able to study a wide range of topics of interest in neutrino physics. In this talk, I will review the latest results from Daya Bay on different fronts, with a focus on the oscillation measurement, the reactor antineutrino flux and spectrum measurements.

Plenary - Underground Physics & Materials Science / 31

Advanced Materials for Nuclear and Particle Physics

Prof. MEI, Dongming [1]

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In this talk, I will address the needed for advanced materials in developing next generation experiments in the searches for dark matter, neutrinoless double-beta decay, and other low-energy neutrino physics. Noble liquids, semiconductors, and phononic materials will be discussed. The criteria of ultra-low background experiments will be applied to the development of advanced materials. We will present several pathways to achieving advanced materials with advanced engineering technologies.

Materials Science / 34

Crystal growth for developing germanium detectors with internal charge amplification for low-mass dark matter

Mr. MEI, Hao [1]; BHATTARAI, Sanjay [2]; SINGH, Mathbar [1]; Prof. MEI, Dongming [3]

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High-purity germanium crystals with diameter up to 12 cm were grown by Czochralski method at the University of South Dakota. The impurity level, charge drift mobility, and resistivity in the crystals were measured by Hall Effect. The mechanical properties such as hardness and Young's modulus were measured to calculate the speed of sound in the Ge sample and thus estimating the energy of longitudinal and transverse phonons as well as the number of phonons generated during the creation of e-h pairs. The results were used to further investigate the avalanche effect for germanium detectors with respect to electric field under different temperatures. This work is supported by NSF OISE-1743790.

Low Background Workshop / 55

Mitigation of Radon-daughter Plate-out for the LZ Experiment

Mr. MORRISON, Eric [1]

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Growing theoretical and empirical evidence for the existence of dark matter has driven a search in the field of physics for its elusive elementary particle. A wide variety of experiments have spawned that include multiple avenues of detection in order to discover the leading candidate, the WIMP. The primary goal of the LUX-ZEPLIN experiment is to detect an interaction between a WIMP and a xenon nucleus which will allow physicists to begin understanding the nature of this exotic type of matter. During each step of the production and construction processes an intense effort is made to hold detector materials to rigorous cleanliness standards so that false positive signals are minimized. An important background arises from charged radon daughters that attach to Teflon and upon decay generate (alpha,n) reactions and recoiling lead-206 atoms. Teflon is a material of particular interest because it is used for the walls of the inner detector and has a radon daughter plate-out rate that can be orders of magnitude larger than the plate-out rate onto other materials. Experiments were conducted where the LZ Teflon was made and where it spends a prolonged period of time exposed to air in order to quantify the plate-out rate in these areas. To mitigate radon contamination and meet LZ cleanliness goals, unique air filtration systems have been constructed to provide low-radon air to locations where materials are exposed during detector assembly. Results detailing the measured radon plate-out rate onto Teflon and the effectiveness of the radon reduction systems will be discussed.

Low Background Workshop / 66

Low Background Counting at SURF

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The BHSU Underground Campus is a cleanroom facility on the 4850'L of the Sanford Research Facility. It currently houses six high purity germanium detectors. An overview of the facility and summary of the detectors will be given.

Parallel - Neutrino Oscillations I / 37

Solar Neutrino Physics with Borexino

Prof. POCAR, Andrea [1]

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Borexino is a large solar neutrino detector running at the Laboratori Nazionali del Gran Sasso since 2007. Neutrinos are detected via their interaction with a 300-ton liquid scintillator target, purified to achieve unprecedented levels of radio-purity. Borexino has detected most of the expected solar neutrino spectrum, as well as anti-neutrinos from Earth's radioactivity and from nuclear reactors with a baseline of ~1,000 km. Recently, neutrinos from the entire pp fusion chain in the Sun have been measured with refined precision using analysis tools that fully exploit our understanding of the detector. Among these, the Beryllium-7 neutrinos are now measured with ~3% precision, which contributes to refining solar models and helps address the solar metallicity problem. These recent results will be presented along with an update on ongoing efforts to measure the last missing tile in the solar neutrino puzzle: CNO neutrinos.

Parallel - Dark Matter I / 16

Data Visualization of the SuperCDMS Experiment

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The Super Cryogenic Dark Matter Search (SuperCDMS) experiment searches for lowmass dark matter and will be located approximately 2 km deep underground in the Sudbury Neutrino Observatory (SNOLAB, Canada). The planned kilogram-scale detector payload is a mix of germanium and silicon detectors placed in four towers. The data acquisition (DAQ) will contain Detector Control and Readout Cards (DCRCs) connected to detectors and a flexible triggering scheme containing hardware and software triggers. Slow control, environmental monitoring, and data quality checking will be integrated into the experimental framework. The near-to-live data quality system enables high experimental efficiency. Data visualization software is being developed for the data quality system. The SuperCDMS experiment, its detector payload, and data acquisition system will be discussed.

Parallel - Dark Matter I / 15

FCPs Search with CDMSlite Run2a

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While free particles with fractional electric charge do not exist in the Standard Model (SM) of particle physics, fractionally charged particles (FCPs) have not been experimentally excluded. The SM of particle physics does have quarks and antiquarks with ±2e/3 and ±e/3 charges, but the strong interaction binds them inside unit-charged hadrons and mesons. FCPs are a feature of viable extensions to the SM with extra U(1) gauge symmetries. Data from CDMSlite Run2a is used for a direct-detection search for energetic FCPs in mass range of 100 MeV to 1 GeV and with electric charge a thousand times less than that of an electron.

Materials Science / 27

Characterizing Germanium (Ge) crystals for developing Ge detectors

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Abstract

The carrier concentration, the mobility of the charge carriers and the resistivity are some of the key electrical properties which are used to know the quality of the grown HPGe crystals in the laboratory. Vander Pauw Hall - effect measurement system is used to measure the above mentioned electrical properties. An optical microscope (Nikon Eclipse LV150L) is used to observe and count dislocations to calculate the dislocation density. By knowing the movement direction of charge carriers affected due to Lorentz force and Hall- effect field, the type of crystal (n or p), carrier concentration, resistivity and mobility can be determined. For most of zone refined ingots, we are able to control the carrier concentration at 10^{11} cm^{-3}, mobility at 4×10^{4} cm^{2} /V·s and the resistivity at 10^{3} Ω - cm. For the grown crystal of 10-12cm, the mobility and resistivity can be kept at the desirable level, the electronic active impurity levels can be achieved at 10^{10}per cm^{3} to meet the detector-grade requirement. We are able to identify the density and the type of dislocation measurements which help to determine the suitable method for crystal growth. We observed that the dislocation density across the large grown crystal may not distribute uniformly. The dislocation density existing in grown crystals has been in the range of 10^{2} -10^{4}per cm^{3}.In addition, photo-thermal ionization spectroscopy (PTIS) is used to identify the impurities in crystals at 7K using helium cryostat.

Parallel - Neutrino Oscillations II / 78

New Results from the Double Chooz Experiment

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In 2011, Double Chooz reported the first strong evidence for a non-zero value of the neutrino mixing angle θ13
by looking at oscillations of electron antineutrinos from a nuclear power plant at Chooz/France. The
observation was derived by measuring inverse beta decay (IBD) events in a single detector located ~1 km from two nuclear reactor cores. Since then, the collaboration has honed the precision of its sin^2(2θ13) measurement
by reducing backgrounds, improving detection efficiency and systematic errors, and including additional
statistics from IBD events with neutron captures on hydrogen.
Since 2014, Double Chooz collects data with a near detector as well, reducing its largest systematic uncertainty.
We present results from a subset of three years of Double Chooz 2 detectors data: 2015 – 2017 with a novel IBD detection,
improved statistics and systematics as well as confirmed background model with reactor-off data.

Plenary - Native American Culture / 43

Native American Heritage

RENCOUNTRE, Whitney [1]

[1] Rural America Initiatives

Poster Session / 70

DUNE 3DST Near Detector

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The Deep Underground Neutrino Experiment (DUNE) is a world-wide experimental high energy physics project with different physics objectives such as: measurement of the CP violation phase, proton decay and supernova neutrino burst using the LArTPC detector (liquid argon time projection chamber). DUNE will be composed of two neutrino detectors exposed to the world's most intense neutrino beam. The near detector will be placed ~ 574 meters from the neutrino source at Fermilab, and the far detector will be located ~1300 km away. The far detector will be placed ~1.4 kilometer underground at the Sanford Underground Research Facility (SURF) in South Dakota.

In this poster, we will focus on the near detector, in particular a three dimensional detector tracker called 3DST, which is a highly segmented plastic scintillator detector. With 3DST we expect to have a 4pi angle coverage for charged particles, as well as good energy and angular resolutions. Due to fine granularity, 3DST is suitable for monitoring the beam profile and due to fast timing, it has great potential to measure neutron energy. Furthermore, 3DST is a bridge to the world scintillator measurements.

Plenary - Geology & Biology / 80

Rock Properties and Fracturing at the Sanford Underground Research Facility

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The 4850 Level of SURF has been the site of rock mechanics experiments aimed towards understanding the fracturing process in rock since 2015. At that time the kISMET project (permeability [k] and Induced Seismicity Management for Energy Technologies) began a program of drilling five vertical holes, the center of which was hydraulically fractured. The other, closely-spaced holes were outfitted with geophysical monitoring technologies including CASSM (Continuous Active-Source Seismic monitoring) and electrical resistivity tomography (ERT). The CASSM data was useful in imaging the fracturing process and subsequent stimulations of the fracture zone, and the project was successful in determining the direction and magnitude of the minimum horizontal stress. Following the kISMET work, a new and much more ambitious project, EGS Collab (Enhanced Geothermal Systems), was initiated, and this project is currently underway. One of the most important objectives of this program is the validation of coupled process models using a large scale test site. In order to develop the test bed, a series of eight 60 m long boreholes were drilled. The injection borehole, which was hydraulically fractured, was drilled parallel to the minimum compressive stress in the rock as was the production borehole. Given this geometry, fractures developed should be perpendicular to these boreholes and the subsequent water flow used to evaluate heat extraction from the rock should progress from the injector to the production borehole about 10 m away. The remaining six 60 m boreholes, two that are parallel to the injection and production boreholes and four that are perpendicular, are devoted to the installation of monitoring instrumentation. The fracturing and water movement is being monitored using CASSM, ERT, distributed temperature sensing systems (DTS), microearthquake sensing systems (MES), tracers introduced in the flow water, and downhole video cameras. The flow paths are complicated by the interaction between the induced fracture system and the naturally-occurring fractures that are delineated by expressions of water movement into the drift, identification of fractures in cores acquired during drilling, tracer tests, and geophysical monitoring.

Parallel - Neutrinoless Double-Beta Decay I / 0

Results from the CUORE experiment

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The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for neutrinoless double beta decay ($0\nu\beta\beta$) that has been able to reach the one-ton scale. The detector consists of an array of 988 TeO_2 crystals arranged in a compact cylindrical structure of 19 towers. The construction of the experiment was completed in August 2016 with the installation of all towers in the cryostat. Following a cooldown, diagnostic, and optimization campaign, routine data-taking began in spring 2017. In this talk, we present the $0\nu\beta\beta$ results of CUORE from examining a total TeO_2 exposure of 86.3 kg·yr, characterized by an average energy resolution of 7.7 keV FWHM and a background in the region of interest of 0.014 counts/(keV·kg·yr). In this physics run, CUORE placed the current best lower limit on the 130Te $0\nu\beta\beta$ half-life of > 1.3 × 10^25 yr (90% C.L.). We then discuss the additional improvements in the detector performance achieved in 2018, the latest evaluation of the CUORE background budget, and we finally present the most precise measurement of the 130Te $2\nu\beta\beta$ half-life to date.

Low Background Workshop / 36

Measuring cosmogenic activation rates in active detector material

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Long-lived radioactive isotopes produced by cosmogenic activation are a major source of background for rare event searches such as dark matter and neutrinoless double beta decay. Understanding the production rates of these cosmogenic isotopes is extremely important for determining the total allowable surface residence time of detector materials during fabrication, storage, and transportation. However, experimentally measuring the production rate is difficult due to low specific activities and because several of the decays of interest produce low energy electrons and x-rays that are not easily detectable. I will discuss a measurement technique that uses a high intensity neutron beam (with a spectrum similar to cosmic ray neutrons) in conjunction with low-background self-counting methods to determine production rates in active detector materials. Based on this technique I will present results from the first experimental measurement of 39Ar and 37Ar cosmogenic production rates in argon, ongoing work on the first measurement of cosmogenic tritium production in silicon, and possible applications to other detector materials.

Plenary - Dark Matter / 40

Dark Matter Overview

Prof. SANDICK, Pearl [1]

[1] University of Utah

The question of the identity of dark matter remains one of the most important outstanding puzzles in modern physics. I'll discuss the evidence for dark matter and some of the leading explanations for the observed phenomena. I'll also give a brief overview of the variety of strategies that are being pursued to "discover" dark matter, focusing on those relevant for so-called Weakly Interacting Massive Particles (WIMPs).

Poster Session / 68

CASPAR - Nuclear Astrophysics Underground

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The CASPAR mainly focuses on Stellar Nucleosynthesis, its impact on the production of heavy elements and study the strength of stellar neutron sources that propels the s-process, 13C(□,n)16O and 22Ne(□,n)25Mg. Currently, implementation of a 1MV fully refurbished Van de Graaff accelerator that can provide a high intensity α beam, is being done at the Sanford Underground Research Facility (SURF). The accelerator is built among a collaboration of South Dakota School of Mines and Technology, University of Notre Dame and Colorado School of Mines. It is understood that cosmic ray neutron background radiation hampers experimental Nucleosynthesis studies, hence the need to go underground in search for a neutron free environment, to study these reactions at low energies is evident. The first beam was produced in the middle of summer 2017. The entire accelerator will be run before the end of this year. A detailed overview of goals of CASPAR will be presented.

Low Background Workshop / 5

Measurement of the Gamma Ray Background in the Davis Cavern at SURF

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The LUX-ZEPLIN (LZ) experiment will search for dark matter particle interactions with a liquid xenon TPC located within the Davis cavern at the Sanford Underground Research Laboratory. Whilst the underground environment is ideal for low background searches due to the attenuation of cosmic rays, a background from gamma-rays emitted from the decays of 40K and the 238U and 232Th chains within the cavern rock must be considered and characterised. I will report on a series of gamma-ray measurements performed inside the cavern with a sodium iodide detector, the determination of isotope concentrations in the cavern walls using comparison to a simulated model, the effect of radon in the cavern air and the expected backgrounds for the LZ experiment.

Parallel - Dark Matter I / 29

The DAMIC dark matter experiment: status and prospects

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The DAMIC (Dark Matter in CCDs) experiment uses fully depleted silicon CCDs (Charge Coupled Devices) to search for dark matter particles. We will present data from a 42-gram detector installed at SNOLAB which demonstrate the CCDs' excellent energy and spatial resolutions, low-energy threshold and unique capability to identify surface and bulk radioactive backgrounds. We will also report on the current activities towards the construction of DAMIC-M -- a kg-size detector to be installed at the Laboratoire Souterrain de Modane in France -- which will feature single-electron charge resolution and a background level of a fraction of dru.

Parallel - Neutrinoless Double-Beta Decay I / 51

The nEXO Experiment

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nEXO detector is a next generation experiment searching for neutrinoless double beta decay of Xe-136. The 5-tonne liquid xenon Time Projection Chamber detector improves upon the design and success of the EXO-200 experiment. The nEXO experiment has developed a design with a projected half-life sensitivity two orders of magnitude greater than previous experimental results. The science goals, detector design, and current R efforts will be discussed. LLNL-ABS-773671

Tyana Stiegler for the nEXO Experiment
Lawrence Livermore National Laboratory

Poster Session / 19

Radiological Simulations and Prototype Data Analysis for the Underground Deep Underground Neutrino Experiment (DUNE)

Mr. STOCK, Jason [1]; Dr. REICHENBACHER, Juergen [2]

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The far detector of the long-baseline neutrino experiment DUNE will be sited underground at the Sanford Underground Research Facility (SURF) in Lead/SD. DUNE is scheduled to have its first 10 kton liquid argon detector module at SURF operational in 2024. The final DUNE far detector will be comprised of four individual 10 kton liquid argon modules.

In order to ensure experimental success, particularly for DUNE's supernova neutrino, solar neutrino and proton decay search programs, radiological backgrounds must be modeled in computer simulations to validate the radiological requirements on detector materials. This work is a vital input for the design of DUNE's far detector at SURF, its read-out electronics, and validation analysis of neutrino detection performance as well as proton decay sensitivity. As the experiment moves out of the design phase and into construction, the electronic systems and computing resources for event triggers must be finalized. Low-energy backgrounds will drive DUNE's expected data rates. The radiological background studies done here at SDSMT are key in this effort, as do the software and simulation tools we have developed.

Presented are the ongoing efforts in the study of radiological backgrounds needed to ensure DUNE is able to accomplish all of its physics goals, as well as first results with DUNE prototype data that can be applied to a future neutrino oscillation analysis with DUNE.

Low Background Workshop / 22

Radon Background Control for the SuperCDMS SNOLAB Dark Matter Experiment

Mr. STREET, Joseph [1]

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The Super Cryogenic Dark Matter Search (SuperCDMS) SNOLAB experiment will use solid-state germanium and silicon cylindrical detectors to measure ionization and phonons produced by the scattering of dark matter particles. The dominant expected background at low energy for SuperCDMS SNOLAB comes from radon daughters that have plated out onto detector surfaces. Therefore, understanding and mitigating plate-out rates during detector fabrication, assembly, and installation is crucial. A study of radon-daughter plate-out during detector polishing and assays of plate-out onto detector hardware provide limits on backgrounds. I will describe the construction and commissioning of the SuperCDMS SNOLAB radon mitigation system, which is built upon the design of the SD Mines prototype radon mitigation system that has achieved a 3800× reduction of radon to a cleanroom activity of ~20 mBq/m^3, and show the resulting expected background from radon daughters for the experiment. Recent results from an acid etch cleaning of the crystal to reduce otherwise dominant sidewall backgrounds without damaging sensors on the detector faces will also be shown.

Plenary - Nuclear Physics / 69

Nuclear Astrophysics Underground - from CASPAR to DIANA

Prof. STRIEDER, Frank [1]

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Even more than 60 years after the groundbreaking publication by Burbidge, Burbidge, Fowler, and Hoyle, Nuclear Astrophysics is still a thriving and exciting research 1eld at the interface of nuclear physics, astrophysics, and particle physics. An important current topic is associated with the evolution of stars and its impact on the production of heavy elements. The most critical reactions are 12C(α,γ)16O, 13C(α,n)16O, 22Ne(α,n)25Mg as well as 12C+12C fusion but other (p,γ), (α,γ), or (α,n) reactions may also play a role depending on the stellar environment. The study of these reactions at stellar energies has been a major goal by the community, in Europe, the US and increasingly also in China. However, the large cosmic ray induced background has been prohibitive for advancing these measurements into the stellar energy range and the present reaction rates rely on theoretical extrapolations that carry high uncertainties.
Accelerator laboratories, located deep underground offer unique conditions for measuring these reactions at low energies as demonstrated by the success of the LUNA facility at Gran Sasso, Italy.
Luna showed for the case of hydrogen burning reactions that many of these kinds of extrapolations can be signi1cantly improved. Over the past years the CASPAR (Compact Accelerator System for Performing Astrophysical Research) laboratory has been constructed and commissioned at the Sanford Underground Research Facility (SURF) at former Homestake Gold mine (Lead, South Dakota, USA) to address the further need for such facilities. CASPAR operates a 1MV, high intensity, fully refurbished Van de Graaff accelerator that can provide beam intensities of more than hundred micro-Ampere.
Furthermore, the LUNA-MV facility in Gran Sasso and as well as the JUNA project in Chinas Jinping Underground Laboratory will be operational in the near future. Successful implementation of a science program at these facilities will offer great opportunities for signi1cant progress in the 1eld. The programs and the current status of the upcoming and existing underground accelerator facilities for Nuclear Astrophysics will be reviewed.

Parallel - Neutrino Oscillations I / 23

Physics of the Theia Detector

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The idea of a Water-based Liquid Scintillator (WbLS) for the LBNF has been developed in a series of international workshops over the lest three years. The Theia detector concept, designed specifically for the LBNF, is the culmination of these workshops. In this talk I present the physics case for Theia, which will be sensitive to solar neutrinos, diffuse supernova flux, and "invisible" nucleon decay in addition to being an excellent detector for long-baseline physics. Results from the WbLS and fast timing R are presented, along with plans to further develop Theia under the ANNIE and WATCHMAN programs.

Low Background Workshop / 18

Neutron Calibration and Simulation for the LZ Dark Matter Experiment

Mr. TIMALSINA, Madan [1]; Dr. REICHENBACHER, Juergen [1]

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Madan Timalsina
Poster presentation
Neutron Calibration and Simulation for the LZ Dark Matter Experiment
Co-author: Dr. Juergen Reichenbacher
Mentor/Advisor: Dr. Juergen Reichenbacher, Department of Physics
The LZ Dark Matter Experiment will perform the most sensitive direct search for weakly-interacting massive dark matter particles (WIMPs). The experiment will be located underground at SURF (Sanford Underground Research Facility) in Lead/SD. The LZ central detector will not only be an order of magnitude larger than the previous LUX inner detector decommissioned at the same location, but its sensitivity for direct dark matter searches will be even 100 times better than LUX.

Dedicated neutron calibration sources such as the DD-generator gun, AmLi and Cf-252 neutron sources, as well as a new mono-energetic Y/Be neutron source are essential tools to precisely map the nuclear recoil (NR) region. Simulation mock data challenges, prior to LZ getting real data, serve as an important validation of the full simulation and data analysis chain, such that there will be a quick, competitive turn-over, once LZ gets its first real data in 2020. The cosmogenically activated natural isotope 131mXe that decays away once the detector is shielded underground from cosmic rays, will be utilized for the first calibration measurement. Further, staged data for calibrations will involve neutron source deployments to map out the NR signal band and gamma-ray source deployments to map out the electron recoil (ER) background band.

In addition to performing extensive computer simulations, the precise neutron fluxes of the various neutron calibration sources have to be characterized before the actual deployments of the sources will be performed. It has to be assessed beforehand, if they are suitable and what the detection efficiency in the detector is. A new neutron telescope, utilizing He-3 proportional counter tubes, has been developed within the framework of the LZ project.

Poster Session / 17

Neutron Calibration and Simulation for the LZ Dark Matter Experiment

Mr. TIMALSINA, Madan [1]; Dr. REICHENBACHER, Juergen [1]

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Madan Timalsina
Poster presentation
Neutron Calibration and Simulation for the LZ Dark Matter Experiment
Co-author: Dr. Juergen Reichenbacher
Mentor/Advisor: Dr. Juergen Reichenbacher, Department of Physics
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Plenary - Nuclear Physics / 62

First underground measurements at CASPAR

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Nuclear astrophysics experiments have the need to measure reactions at low energies in order to understand the reaction rates at stellar temperatures. The low yields at these energies have prompted the need for underground experiments to reduce the environmental background. Despite this reduction, experiments can still be limited by the intrinsic background of a detector. To address this problem, we have implemented pulse shape discrimination utilizing the rise time of the signal for the CASPAR neutron detector system. CASPAR is located at the 4850' level of the Sanford Underground Research Facility (SURF) located in Western South Dakota and is the first deep underground accelerator facility in the United States. This pulse shape discrimination technique will be presented, along with some initial results of its application to recent low energy measurements of 11B(α,n)14N.

Parallel - Dark Matter III / 32

Review of the NEWS-G experiment

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New Experiments with Spheres-Gas (NEWS-G) is a dark matter direct detection collaboration that aims to detect low mass WIMPs using Spherical Proportional Counters (SPCs). This ionization detector consists in a metallic sphere filled with noble gas, and a high voltage electrode in its centre. This technology has many appealing features, such as sub-keV thresholds and flexibility in the target gas for use in different searches. A first prototype of an SPC located in the Laboratoire Souterrain de Modane (LSM) has already set leading limits in the sub-GeV space of Dark Matter direct detection searches. In this talk, we will give an overview of the detector technology, including a description of the current work being done in the development of new sensors, calibrations, and quenching measurements. We will finally give a status update on the upcoming NEWS-G experiment at SNOLAB, expected to improve significantly over the results of smaller first-generation detector at LSM.

Plenary - Geology & Biology / 79

Development of Thermal Breakout Technology for Determining the Maximum Horizontal In Situ Stress

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The current state-of-the-art technology for in situ stress measurements involves an integrated approach that combines borehole breakout observations, drilling-induced tensile fractures, and hydraulic fracturing tests (i.e., mini-fracs). This methodology has achieved wide application in the oil-and-gas industry but has several limitations that often prevent successful in situ stress measurements. One major limitation is that breakouts do not appear in all boreholes and are generally only a natural occurrence that cannot easily be controlled. Because borehole breakouts are used to directly measure the maximum horizontal in situ stress magnitude, the absence of borehole breakouts presents a major data gap for in situ stress measurements. In response to this data gap, a new Department of Energy- (DOE-) sponsored thermal breakout technology that will provide a method for thermally inducing borehole breakouts and allow the consistent measurement of the maximum horizontal stress magnitude is currently in development. This thermal breakout technology involves heating the borehole and increasing the thermoelastic compressive stress in the rock until a breakout develops, which can be directly correlated to the maximum horizontal stress magnitude. This presentation will discuss some of the preliminary modeling, laboratory testing, and field testing (at the Sanford Underground Research Facility) results of the thermal breakout research project.

Plenary - Neutrino Oscillations / 72

Status of the Deep Underground Neutrino Experiment (DUNE)

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The Deep Underground Neutrino Experiment (DUNE) is a next-generation long baseline neutrino oscillation experiment in the USA, with primary goals of determining the neutrino mass ordering, measuring the CP violating phase, searching for proton decay, and detecting the supernova neutrinos. DUNE will send the world's most intense neutrino beam produced at Fermilab to the 40 kiloton Liquid Argon far detector at the Sanford Underground Research Facility (SURF) in South Dakota, through a 1300 km baseline. The ambitious physics program of DUNE involves highly collaborative international contributions and extensive prototyping and testing efforts. This talk will describe the DUNE experiment, its current status, its physics program, and the ProtoDUNE prototyping program that is currently ongoing at the CERN Neutrino Platform.

Materials Science / 35

Investigation of Amorphous Germanium Contact Properties with Planar Detectors Made from USD-Grown Germanium Crystals

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The characterization of detectors fabricated from home-grown crystals is the most direct way to study crystal properties. We fabricated planar detectors from high-purity germanium (HPGe) crystals grown at the University of South Dakota (USD). In the fabrication process, a HPGe crystal slice cut from a USD-grown crystal was coated with a high resistivity thin film of amorphous Ge (a-Ge) followed by depositing a thin layer of aluminum on top of the a-Ge film to define the physical area of the contacts. We investigated the detector performance including the I-V characteristics, C-V characteristics and spectroscopy measurements for a few detectors. The results document the good quality of the USD-grown crystals and electrical contacts. This work is supported by NSF OISE-1743790 and NSF PHY-1902577.

Poster Session / 52

Environmental Effects on Light Guide Polymers

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The goal of this experiment was to test the environmental survivability of two possible light guide components for the Deep Underground Neutrino Experiment (DUNE) Single Phase detector. Four wavelength shifting plates and one coated acrylic bar were exposed to a variety of high humidity and high temperature conditions for an average of 700 hours. The wave shifted light produced when the plates and bar were exposed to 285nm light was then measured periodically to test their response to the environmental conditions. The resulting data were then processed using the ROOT analytical package. The testing demonstrated consistent wave shifting properties of the plates despite the environmental stresses.

Parallel - Neutrinoless Double-Beta Decay II / 56

Current status of the Majorana Demonstrator and outlook for LEGEND

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The Majorana Demonstrator is a neutrinoless double beta decay experiment operating at the 4850' level of the Sanford Underground Research Facility. Its goal is to operate a low-background array of high-purity germanium (HPGe) detectors, a key milestone on the path to the ton-scale LEGEND experiment. It has been operating in its current configuration since early 2017, amassing more than 30 kg-y of exposure with its HPGe detectors enriched to 88% 76Ge. Its physics data set has been used to search for other physics beyond the Standard Model, including bosonic dark matter, lightly ionizing particles, and tri-nucleon decay. In addition, both the Majorana and GERDA Collaborations have developed robust analysis methods that will be directly applicable to the next generation of HPGe experiments, LEGEND-200 and LEGEND-1000. In this talk, I will review the key physics and technical results from the Majorana Demonstrator, and describe the current status of the LEGEND project.

Parallel - Neutrino Oscillations I / 11

The KATRIN neutrino mass experiment

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The objective of the Karlsruhe Tritium Neutrino experiment (KATRIN) is the measurement of the effective electron neutrino mass with an unprecedented model-independent sensitivity of 0.2 eV/c^2. This will improve present limits by one order of magnitude and allows to constrain the role of relic neutrinos as hot dark matter in structure evolution.

A non-zero neutrino mass in the sub-eV range induces only a minute deviation of the β-decay spectrum close to the kinematic endpoint. In the case of KATRIN, high-purity molecular tritium is used as β-emitter. The components of KATRIN, a high intensity window-less tritium source (~10^{11} Bq), and a huge 24-m long electrostatic spectrometer (MAC-E-filter) with an energy resolution of 1 eV at the β-endpoint of 18.6 keV guarantee high precision spectroscopy. The overall 70-m long setup is operated at the Karlsruhe Institute of Technology (KIT) by an international collaboration of about 150 scientists.

This talk describes the goals, challenges, and performance of the experiment and reports on the status of the ongoing tritium measurement.

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Parallel - Neutrino Oscillations I / 77

Recent Physics Results of the MicroBooNE Experiment

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MicroBooNE is currently the longest running liquid argon neutrino detector in the world located at Fermilab in Batavia, Illinois. The experiment was designed to study short baseline neutrino physics from the on-axis Booster Neutrino Beam (BNB). Utilizing the excellent ability of liquid argon time projection chambers (LArTPC) to perform electron/photon separation, MicroBooNE aims to understand the source of the excess of electromagnetic events observed by MiniBooNE as well as to perform neutrino-argon cross section measurements to high precision while providing crucial input towards the future LArTPC detectors. This talk will give an overview of the MicroBooNE experiment and highlight recent physics results.